

chapter v

Technological Attainability of the Refined Recommended Tidal-Water Designated Uses

BACKGROUND

Chapter IV presented the rationale for delineating the refined tidal-water designated uses and their boundaries on the basis of physical conditions, bathymetric features and insights into natural conditions versus anthropogenic influences through the analysis of Chesapeake Bay water quality monitoring data. The next step is to determine whether the water quality criteria protecting each of these designated uses can be achieved throughout each use's proposed boundaries strictly on the basis of technological implementation of nutrient and sediment controls, or on the basis of the historical presence of underwater bay grasses.

A use attainability analysis (UAA) is not required to justify refined designated uses, particularly in areas where they will be more stringent than they are at present. However, the Chesapeake Bay watershed partners agreed that it was as important to document the future attainability of the refined tidal-water designated uses as it was to show why current designated uses could not be achieved in some tidal habitats.

For dissolved oxygen, the criteria that apply throughout the designated use boundaries were compared to model-simulated dissolved oxygen concentrations under a range of technological scenarios. These scenarios, or tiers, estimate the nutrient and sediment reductions resulting from the implementation of various best management practices (BMPs) and control technologies. The tier scenarios were run through the Chesapeake Bay Program's Phase 4.3 Watershed Model, and the resulting nitrogen, phosphorus and sediment loads delivered to tidal waters were entered into the Chesapeake Bay Water Quality Model. The water quality model-simulated ambient dissolved oxygen concentrations were assessed, based on comparisons with the applicable criteria in each refined designated use. Finally, water quality responses resulting from the load reductions represented by each tier were arrayed and compared. A series of 'attainability tables' illustrates these comparisons and indicates where the dissolved oxygen criteria, per each refined designated use, were and were not attained in the Chesapeake Bay and its major tidal tributaries.

The Chesapeake Bay Program partners performed these attainability analyses with respect to the monthly dissolved oxygen criteria proposed for each designated use. Sufficient data providing the basis for the other averaging periods (e.g., weekly, daily or instantaneous minimum) do not currently exist.

For the shallow-water designated use, the Chesapeake Bay Program partners assessed attainability by evaluating past and present abundance and distribution of underwater bay grasses. While water clarity is the water quality criteria applicable to protecting this designated

use, implementation of these criteria will be coupled with regional and local scale underwater bay grass acreage data for attainment assessment. Rather than assessing attainability based on clarity, it is appropriate to base attainability relative to the resource requiring restoration. The Chesapeake Bay Program partners determined that the historic and recent records showing the unequivocal presence of underwater bay grasses to be sufficient documentation to justify the attainability of their presence in the future.

The *Technical Support Document* does not address attainability for chlorophyll *a* because this criteria is expressed in narrative terms and does not include numeric values at the baywide scale around which to perform attainability analyses (U.S. EPA 2003). As the four jurisdictions with Chesapeake Bay tidal waters derive specific numerical values for chlorophyll *a* criteria for application to local tidal waters where algal-related impairments are expected to persist after the dissolved oxygen and water clarity criteria have been attained, it will be up to those jurisdictions to assess attainability based on those concentrations.

DEFINING AND DETERMINING TECHNOLOGICAL ATTAINABILITY FOR DISSOLVED OXYGEN

The nutrient and sediment reduction tier scenarios are described in terms of their respective BMP and control technologies and the resulting load reductions. The water quality response realized by the theoretical implementation of each tier is estimated and an assessment is made of whether this response is sufficient to attain the dissolved oxygen criteria applicable to each of the refined designated uses.

Development of Level-of-Effort Scenarios

The Chesapeake Bay Program partners developed a series of level-of-effort scenarios to represent the potential for reducing nutrient and sediment loads from the Chesapeake Bay watershed in terms of the types, extent of implementation and performance of BMPs, wastewater treatment technologies and storm water controls. These scenarios range from Tier 1, which represents the current level of implementation throughout the watershed plus regulatory requirements implemented through the year 2010, up to a limit of existing technologies scenario referred to as ‘everything, everywhere by everybody’, or the E3 scenario, which is acknowledged by Bay Program partners not to be physically possible in all cases. Two intermediate levels of implementation also were developed, Tier 2 and Tier 3. Each tier has associated with it a given nitrogen, phosphorus and sediment load reduction resulting from model-simulated implementation of the different technologies assigned to the tier.

As the introduction to the *Technical Support Document* stresses, these tiers are artificial constructs of technological levels of effort and *do not represent actual programs that the Chesapeake Bay watershed jurisdictions will eventually implement to meet the water quality standards*. Rather, the tiers were developed as an assessment tool to determine potential load

reductions achievable by various levels of technological effort yielding different tidal-water quality responses.

Water quality responses yielding attainment of the Chesapeake Bay criteria were simulated by the Chesapeake Bay Water Quality Model under the nutrient and sediment reductions represented by The E3 scenario and, to a great extent, by Tier 3. The technologies and their performance capabilities are known to be available; however, the technological and physical feasibility of their implementation has not been proven. Additionally, the tiers were constructed on a basinwide scale, distinct from local circumstances. The partners agree that the E3-level nutrient and sediment reductions are not physically plausible and that the load reductions represented by Tier 3 are technologically achievable. However, the mix of technologies employed to achieve the load reductions at Tier 3 will be up to the jurisdictions as they consider local situations, capabilities and the cost-effectiveness of reduction practices within their specific tributary basins.

The Chesapeake Bay Program partners developed the tiers primarily on the basis of the amount of nutrient (nitrogen and phosphorus) reductions afforded by the various practices and technologies described in each. Upland sediment load reductions were estimated as resulting from implementation of BMPs directed toward reducing nutrient loads. Other sediment reduction practices are available, and may, if implemented along with nutrient reduction efforts, afford additional water quality improvements. The primary benefit from sediment load reductions is increased light for the restoration of underwater bay grasses (see “Measures to Attain the Shallow-Water Designated Use,” below).

The Chesapeake Bay Program Nutrient Subcommittee’s ‘source’ workgroups defined the tiered scenarios. Representatives of the Chesapeake Bay watershed jurisdictions and Chesapeake Bay Program office personnel comprise these workgroups. The workgroups that decided BMP and technology implementation levels included the Agricultural Nutrient Reduction Workgroup, the Forestry Workgroup, the Point Source Workgroup and the Urban Storm Water Workgroup. The Tributary Strategy Workgroup and Nutrient Subcommittee finalized The E3 scenario definitions after review and further deliberation. The tiers were developed for the following source categories:

- Point sources
- Onsite treatment systems
- Nonpoint source agriculture
- Nonpoint source urban
- Nonpoint source forests

The following sections summarize the technologies that will enable progressively higher levels of reductions by tier according to the source categories listed above. Appendix A describes the development of these tiers and the technologies represented by each, along with Chesapeake Bay Watershed Model-simulated nitrogen, phosphorus and sediment load reductions resulting from the implementation of the tiers.

Point Sources

A multistakeholder Nutrient Removal Technology (NRT) Cost Task Force, consisting of federal, state and local governments as well as municipal authority representatives and consultants, was formed as a temporary extension of the Chesapeake Bay Program's Nutrient Subcommittee Point Source Workgroup. The task force defined logical tiers (or different nutrient reduction levels) for point sources (U.S. EPA 2002). Using flows estimated or projected for the year 2010, the tiers range from the current year 2000 treatment levels to the levels of existing control technologies.

The point sources analyzed in this effort include facilities located in the Chesapeake Bay watershed (including Pennsylvania, Maryland, Virginia, Delaware, West Virginia, New York and the District of Columbia), which the watershed jurisdictions have determined discharge significant amounts of nitrogen and phosphorus (Table V-1). These point sources were divided into several categories for the purpose of this UAA.

- Significant municipal facilities, usually municipal wastewater treatment plants, that discharge flows of equal to or greater than 0.5 million gallons per day (MGD);
- Significant industrial facilities that discharge equivalent to or greater quantities of nutrients than that discharged by a municipal wastewater treatment plant (0.5 MGD);
- Nonsignificant municipal facilities with discharge flows smaller than 0.5 MGD, limited to facilities in Maryland and Virginia due to the availability of data; and
- Combined Sewer Overflows (CSOs), which, for this assessment, include the CSO for the District of Columbia (the only CSO for which the Chesapeake Bay Program has nutrient load data).

Table V-1. Point source tiered scenario descriptions.*

Point Source Category	Tier 1	Tier 2	Tier 3	E3
Significant Municipals	TN = 8 for publically-owned treatment works (POTWs) operating (or planned) NRT TN for remainder = 2000 concentrations. TP = 2000 concentrations, except TP = 1.5 in those targeted by VA.	TN = 8; TP= 1.0 or permit limit if less	TN = 5; TP = 0.5 or permit limit if less	TN = 3.0; TP = 0.1
Significant Industrials	TN and TP = 2000 concentrations or permit limit if less	Generally a 50% reduction from Tier 1 (2000 concentrations) or permit conditions if less	Generally an 80% reduction from Tier 1 (2000 concentrations) or permit conditions if less	TN = 3.0; TP = 0.1 or permit conditions if less
Nonsignificant Municipals	TN and TP = 2000 concentrations	TN and TP = 2000 concentrations	TN and TP = 2000 concentrations	TN = 8; TP = 2.0 or 2000 concentrations if less
Combined Sewer Overflows	43% reduction for tiers 1-3			Zero overflow

*Note that all flows are in terms of those projected by 2010, and concentrations of total nitrogen (TN) and total phosphorus (TP) are presented as annual averages in mg/l.

For municipal facilities, the technologies for each tier varied depending on the tiers' nutrient reduction levels. For Tier 2, technologies to achieve 8 mg/l total nitrogen include extended aeration processes and denitrification zones, along with chemical addition to achieve a total

phosphorus discharge of 1.0 mg/l where facilities are not already achieving these levels. For Tier 3, technologies to achieve 5.0 mg/l total nitrogen include additional aeration, a secondary anoxic zone plus methanol addition, additional clarification tankage and additional chemical to achieve a total phosphorus discharge of 0.5 mg/l. For The E3 scenario, technologies to achieve 3.0 mg/l total nitrogen include deep bed denitrification filters and microfiltration to achieve a phosphorus discharge of 0.1 mg/l. Due to seasonal fluctuation, the effluent/discharge levels for each tier were defined as an annual average.

For industries, site-specific information on reductions by facility was obtained via phone or site visits. Tier 1 represents current conditions or plans for reductions that already are in progress. Tiers 2 and 3 generally reflect levels of reduction of 50 percent and 80 percent from Tier 1, respectively, unless permit conditions are less than this or site-specific information provides alternate data. The E3 scenario reflects total nitrogen and total phosphorus concentrations of 3.0 and 0.1 mg/l, respectively, unless permit conditions or actual 2000 concentrations are less than this level. For The E3 scenario, some industrial facilities would be incapable of achieving the discharge concentration/level.

The only combined sewer overflow included in the tiers was the District of Columbia because it is the only one for which the Chesapeake Bay Program has data on resulting nutrient loads. According to the District of Columbia Water and Sewer Authority, overall nutrient loads are expected to be reduced by 43 percent from 2000 levels over the next eight years, and Tier 1 reflects this reduction, which also is carried over into Tier 2 and Tier 3. For the purpose of estimating limits of technology, zero overflows were assumed for The E3 scenario, although the D.C. Water and Sewer Authority stresses that no overflow is not physically possible.

Onsite Treatment Systems

The Chesapeake Bay Program's Point Source Workgroup developed the tiers for onsite treatment systems, or septic systems. Tier 1 involved maintaining current septic concentrations/loads per system equivalent to 36 mg/l total nitrogen. Tier 2 includes 10 percent of new treatment systems installing nutrient reduction technologies to obtain an edge of drainage field total nitrogen concentration of 10 mg/l per system. Tier 2 for existing systems remains the same as Tier 1. Total phosphorus levels are not addressed in the septic system tiers because septic systems are not considered a significant source of phosphorus. Tier 3 involves 100 percent of new treatment systems installing nutrient reduction technologies to obtain an edge of drainage field total nitrogen concentration of 10 mg/l per system, and upgrades 1 percent of existing systems to this level of treatment as well. Note that the Point Source Workgroup thinks it unlikely that existing systems could be retrofitted due to the high cost, thus only 1 percent of existing systems were included in the Tier 3 scenario for retrofit. For The E3 scenario, 100 percent retrofits and upgrades are defined for existing as well as new septic systems.

Nonpoint Source Agriculture

Estimated load reductions for agricultural practices are a function of the definition and assumed efficiency of the BMPs being investigated. For the purposes of this document, all definitions and efficiencies of BMPs assumed for the reduction tiers and included in the model scenarios are described in Appendix H of the Chesapeake Bay Watershed Model Phase 4.3 documentation (Palace et al. 1998). The Chesapeake Bay Program's Nutrient Subcommittee is updating several BMP definitions and efficiencies. The Chesapeake Bay Program will publish these revisions in 2003 in a revised Appendix H total watershed model documentation. The Chesapeake Bay Program encourages the jurisdictions to use the most recent information on BMPs when developing their tributary strategies and adopting their water quality standards.

For most nonpoint source agricultural BMPs, implementation rates between 1997 and 2000 were continued to the year 2010, however, levels could not exceed the available or The E3 scenario land area on which to apply the BMPs (Table V-2). The scale of calculations was by county segment or by the intersection of a county political boundary and a Chesapeake Bay Watershed Model hydrologic segment. This is the same scale that most jurisdictions use to report BMP implementation levels to the Chesapeake Bay Program.

The 2010 Tier 1 BMPs were extrapolated from recent implementation rates by the landuse types submitted by the states for each BMP. For example, if a jurisdiction submits data for nutrient management on crop, 2010 Tier 1 crop was projected and then split among high-till, low-till and hay, according to relative percentages. If a jurisdiction submits data as nutrient management on high-till, low-till and hay individually, projections were done for each of these land use categories.

The 2010 Tier 1 scenario does not include tree planting on tilled land, forest conservation and forest harvesting practices, because these BMPs are not part of the tiers and The E3 scenario. For forest harvesting practices and erosion and sediment control, the model simulation does not account for additional loads from disturbed forest and construction areas, respectively. For forest conservation, planting above what is removed during development is accounted for in the 2010 urban and forest projections. Tree planting on agricultural land was included in Tier 1 for pasture as forest buffers since this BMP is also part of the tiers and The E3 scenario and pasture tree planting and pasture buffers are treated the same in the model.

The 2010 Tier 2 and Tier 3 BMP implementation levels for nonpoint sources were generally determined by increasing levels above Tier 1 by a percentage of the difference between Tier 1 and The E3 scenario levels for each BMP. These percentages were mostly prescribed by individual source workgroups under the Chesapeake Bay Program Nutrient Subcommittee and were applied watershed-wide by county segments or the intersections of county political boundaries and the Chesapeake Bay Watershed Model's hydrologic segmentation.

The BMP levels in The E3 scenario are believed to be the maximum extent feasible. There are no cost and few physical limitations to implementing BMPs for both point and nonpoint sources.

In addition, The E3 scenario includes new BMP technologies and programs that are not currently part of jurisdictional pollutant control strategies.

Riparian forest buffers are particular BMPs under agricultural and urban sources that can be estimated in terms of acres or stream miles. Table A-2 in Appendix A illustrates that riparian forest buffers estimates exist in hay and pasture land uses under agriculture and in pervious and mixed open landuses under urban sources. *Chesapeake 2000* includes a goal to conserve existing forest along all streams and shorelines and to restore riparian forest on 2,010 miles of stream and shoreline in the watershed by 2010. Between 1996 and 2002, 2,283 miles of riparian forest buffers were actually planted in the Chesapeake Bay watershed, surpassing the 2010 goal. The tiers also include estimates of projected riparian forest buffers, and their total one-sided stream miles with 50-foot width are listed below (which can be calculated by adding the total stream miles listed in Appendix A, Table A-2, per tier): Tier 1 – 2,584; Tier 2 – 21,022; Tier 3 – 33,109; and The E3 scenario – 105,579 miles.

Table V-2. Examples of the increasing levels of agricultural nonpoint source BMP implementation by tier.

Agricultural BMP	Tier 1	Tier 2	Tier 3	E3
Conservation Tillage	Continue current level of implementation	Applied to 30% of remaining cropland beyond Tier 1	Applied to 60% of remaining cropland beyond Tier 1	Conservation tillage on 100% of cropland
Cover Crops	Continue current level of implementation	Applied to 40% of remaining cropland beyond Tier 1	Applied to 75% of remaining cropland beyond Tier 1	Applied to 100% of cropland
Stream Protection w/Fencing	Continue current level of implementation	Applied to 15% of remaining stream reaches within pasture land beyond Tier 1	Applied to 75% of remaining stream reaches within pasture land beyond Tier 1	Streambank protection on all unprotected stream miles (each side) associated with pasture

Nonpoint Source Urban

Tier 1 represents voluntary and regulatory storm water management programs that will be in place between 2000 and 2010, including EPA National Pollutant Discharge Elimination System (NPDES) Phase I and II storm water regulations, the construction and effluent development guidelines and state storm water management programs (Table V-3). Tiers 2 and 3 represent

progressively increased levels of voluntary BMP implementation measures beyond Tier 1. The E3 scenario represents the Nutrient Subcommittee's Urban Storm Water Workgroup's understanding of the highest levels of urban BMP protection achievable.

Table V-3. Examples of the increasing levels of urban nonpoint source BMP implementation by tier.

Urban BMP	Tier 1	Tier 2	Tier 3	E3
Storm Water Management—recent development (1986–2000)	60% of recent development has storm water management	Same as Tier 1	Same as Tier 1	See below for 'recent and old development'
Storm Water Management—new development (2001–2010)	66% of new development has storm water management	75% of new development has storm water management; 25% of new development has LID*	50% of new development has storm water management; 50% of new development has LID*	100% of new development has LID*
Storm Water Management—recent and old development (pre-1986)	0.8% of recent and old development is retrofitted	5% of recent and old development is retrofitted	20% of recent and old development is retrofitted	100% of recent and old development is retrofitted

*Low Impact Development

Nonpoint Source Forestry

The forestry BMP levels defined in the tiers are the same throughout the four levels. The tiers reflect an assumption that forestry BMPs are designed to minimize the environmental impacts from timber harvesting such as road building and cutting-and-thinning operations, and are properly installed on all harvested lands with no measurable increase in nutrient and sediment discharge. The assumption is based on maintaining the state of forest loads as measured during the calibration of the Chesapeake Bay Phase 4.3 Watershed Model.

Atmospheric Deposition

The Chesapeake Bay Program modeled four different nitrogen oxide (NO_x) emission reduction scenarios to estimate changes in atmospheric nitrate deposition and loads to the Chesapeake Bay

and its watershed (Table V-4). The first two scenarios describe Clean Air Act (CAA) regulations; the third and fourth scenarios include these existing regulations, as well as emissions controls that are not tied to existing or proposed regulations. All scenarios involve NO_x emissions reductions made by 37 states contained in the EPA Regional Acid Deposition Model (RADM) domain based on the national 1990 NO_x emissions inventory. All the tiered scenarios summarized in Table V-4 include the full array of emission controls described for the preceding tier.

The effects of emission controls and the resulting lower atmospheric deposition to the Chesapeake Bay watershed's land area and nontidal waters are part of the reported nutrient loads from the individual land use source categories in the tiers and The E3 scenario (i.e., agriculture, urban, mixed-open, forest and nontidal surface waters). The reported loads, however, usually do not include contributions from atmospheric deposition directly to surface tidal waters, although the model-simulated water quality responses account for this source.

Table V-4. Atmospheric deposition tiered scenario descriptions and NO_x reduction assumptions.

Tier 1	Tier 2	Tier 3	E3
NO _x state implementation plans (SIPs), assuming implementation by 2007/2010	Tier 1 controls, plus heavy-duty diesel vehicle (HDDV) regulations, assuming implementation by 2020	Tier 1 and 2 controls, plus ‘what if’ aggressive utility controls, assuming implementation by 2020	Tier 1-3 controls, plus ‘what if’ industry and mobile source controls, assuming implementation by 2020
2007 non-utility and area source emissions	2020 non-utility and area source emission standards	2020 non-utility and area source emission standards	2020 non-utility and area source emissions
2007 mobile source—Tier 2 tailpipe standards on Light Duty Vehicles (LDVs) (cars and trucks)	2020 Tier 2 tailpipe standards on LDVs	2020 Tier 2 tailpipe standards on LDVs	Industry (non-utility) emissions at almost 50% for both SO ₂ and NO _x
2010 utility emissions—Title IV (acid rain) fully implemented and Title I 20-state NO _x SIP call seasonal (May-September) ozone controls	2020 Title V and Title I NO _x SIP HDDV Regulations	2020 Title V and Title I NO _x SIP greater emissions reductions from utility sector-annual controls	2020 Title V and Title I SIP greater emissions reductions from utility sector-annual controls Super ultra-low emission vehicle assumed for LDVs

Load Reductions by Tier

The Chesapeake Bay Program’s Phase 4.3 Watershed Model-simulated the tier and E3 scenarios, and the resulting loads for nitrogen, phosphorus and sediment were used as inputs to the Chesapeake Bay Water Quality Model. Evaluation of the simulated water clarity, dissolved oxygen and chlorophyll *a* concentrations from the Water Quality Model, in turn, provided a sense of the response of these key water quality parameters to the various loading levels.

For the tiers, BMP implementation levels, the resulting modeled loads and the measured responses in tidal-water quality are informational. They are not intended to prescribe control measures to meet *Chesapeake 2000* nutrient and sediment loading caps.

Relating BMP implementation levels in the tier scenarios to water quality responses only provides examples of what levels of effort achieve the reported loads and what the water quality responses are to those loading levels. Reported E3 loads from the Chesapeake Bay’s basin,

however, can imply measurable theoretical minimums that would be extremely difficult, if not impossible, to remedy at this time.

Figures V-1 to V-3 illustrate modeled nitrogen, phosphorus and sediment loads, respectively, delivered to the Chesapeake Bay and its tidal tributaries for the four tiered scenarios, excluding atmospheric deposition to tidal waters and shoreline erosion loads. The model-simulated load estimates for the year 2000 and pristine scenario (see Chapter III) are provided as reference points.

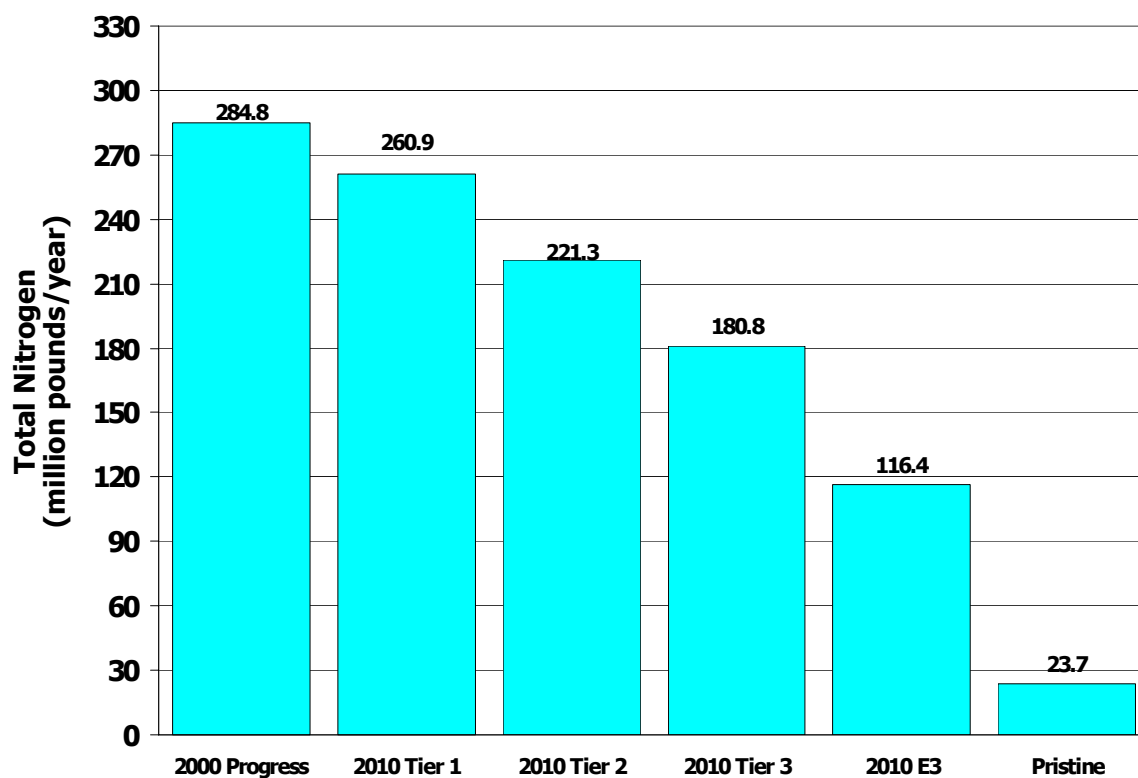


Figure V-1. Model-simulated nitrogen loads delivered to the Chesapeake Bay and its tidal tributaries under the four tiered scenarios.

Source: Chesapeake Bay Program website <http://www.chesapeakebay.net>.

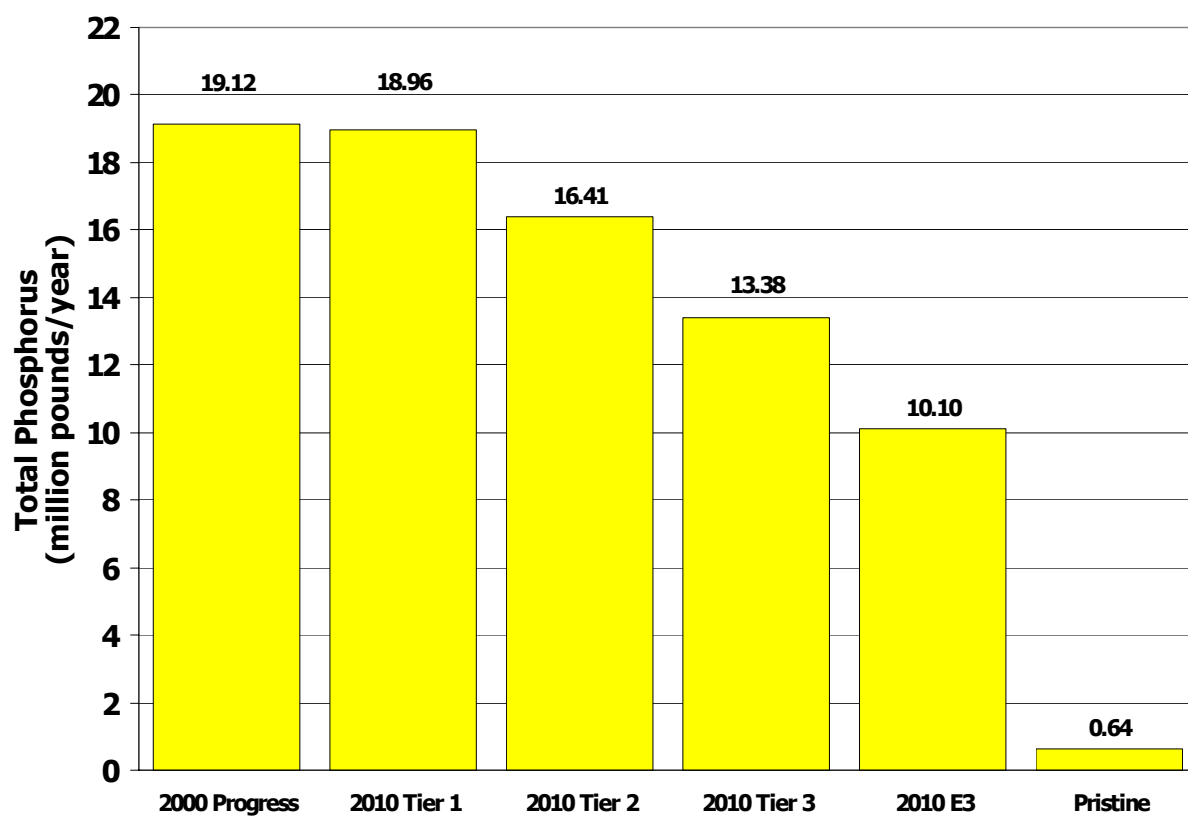


Figure V-2. Model-simulated phosphorus loads delivered to the Chesapeake Bay and its tidal tributaries under the four tiered scenarios.

Source: Chesapeake Bay Program website <http://www.chesapeakebay.net>.

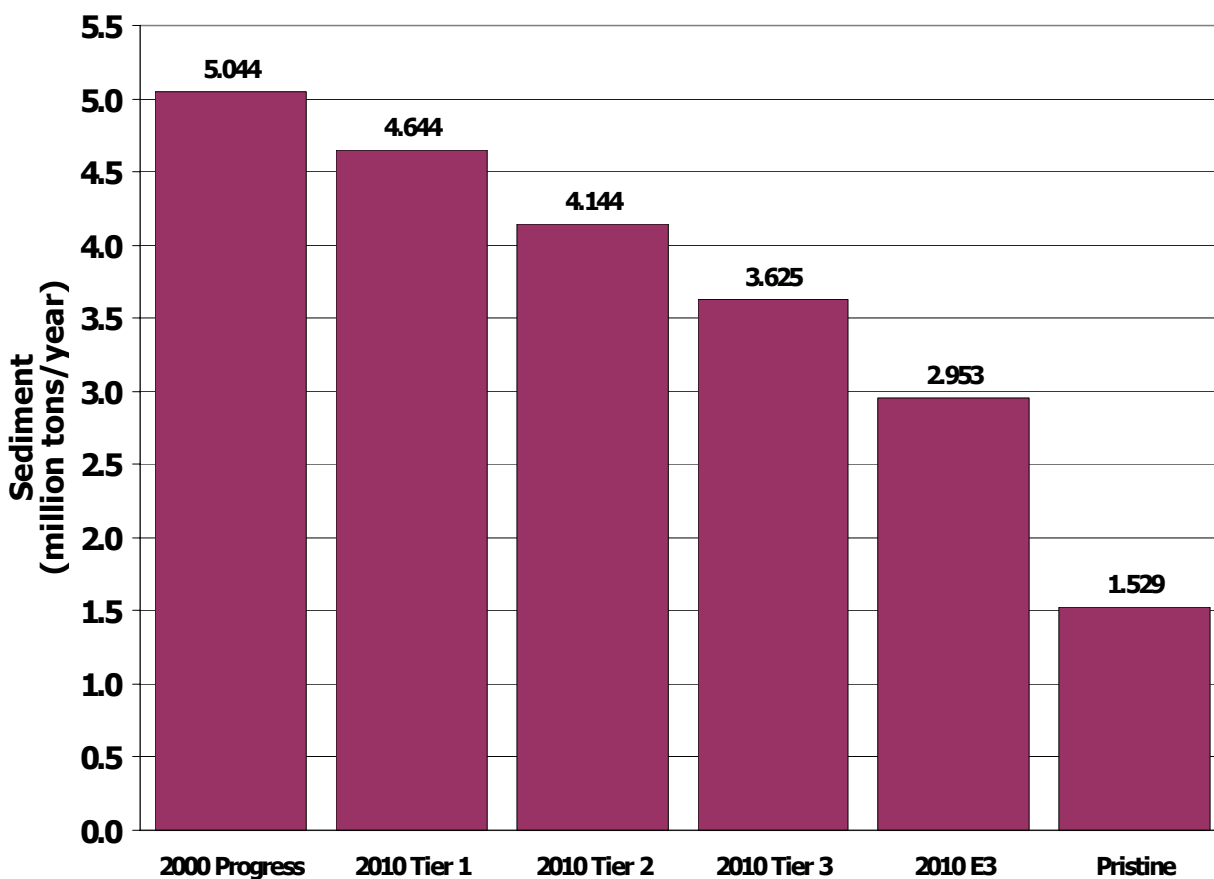


Figure V-3. Model-simulated sediment loads delivered to the Chesapeake Bay and its tidal tributaries under the four tiered scenarios.

Source: Chesapeake Bay Program website <http://www.chesapeakebay.net>.

Development of the Criteria Attainability Tables

A series of coupled Chesapeake Bay airshed, watershed and water quality model scenarios were run to determine the water quality response to the reduction actions represented in each tiered scenario described above. The results of these analyses are presented in a series of technological ‘attainability tables’ which show, on a Chesapeake Bay Program segment-by-segment basis, the level of attainment of the applicable Chesapeake Bay criteria by designated use and tiered scenario. The model-simulated percent criteria attainment, illustrated in the attainability tables that follow, are based on an integrated evaluation of Chesapeake Bay model-simulated output and water quality monitoring observed data. For a full discussion of this integration procedure, see *A Comparison of Chesapeake Bay Estuary Model Calibration with 1985-1994 Observed Data and Method of Application to Water Quality Criteria* (Linker et al. 2002). Results are presented for the 35 major Chesapeake Bay Program segments where management applicable model results are available.

These attainability tables were developed using a comprehensive set of criteria attainment determination procedures described in detail in the EPA’s *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries* (U.S. EPA 2003). In general, modeled dissolved oxygen water quality observations were compared to proposed criteria, on a segment-by-segment basis (see Figure IV-30 and Table IV-11) for a map and listing of the Chesapeake Bay Program monitoring segments) to determine the spatial and temporal extent of nonattainment.¹³ The criteria used to conduct these comparisons were the 30-day mean dissolved oxygen concentrations of 6 mg/l for the migratory and spawning use, 5 mg/l for the open-water use, 3 mg/l for the deep-water use and 1 mg/l for the deep-channel use. The attainability tables do not reflect assessment of the 7-day mean, 1-day mean or instantaneous minimum criteria.

The dissolved oxygen criteria have several different durations: 30-day mean, 7-day mean, 1-day mean (deep water only) and instantaneous minimum. A state’s ability to assess these criteria and to have certainty in the results depends on the time scale of available data and the capacity of models to estimate conditions at those time scales. At present, long-term, fixed-station, midchannel water quality monitoring in the Chesapeake Bay and its tidal tributaries provides dissolved oxygen measurements twice monthly at most or approximately every 15 days between April and August. Proposed enhancements to the tidal-water quality monitoring program include shallow-water monitoring, as well as high-resolution spatial and temporal monitoring in selected locations. However, these new components are only in the planning and early implementation stages at this point, and because of financial constraints or limitations to current technology, direct monitoring at the scales of the criteria may not be possible in the foreseeable future across *all* tidal waters. Therefore, the direct assessment of attainment for some geographic regions and for some short-term criteria elements (e.g., instantaneous minimum, 1-

¹³ Note: The term ‘nonattainment’ is used within the context of comparing dissolved oxygen water quality modeled response to reduction measures with the EPA published Chesapeake Bay water quality criteria. The term is not used here to imply nonattainment with respect to CWA 303(d) lists.

day mean and 7-day mean) must be waived for the time being or based on statistical methods that estimate probable attainment (U.S. EPA 2003).

Assessing Criteria Exceedance through the Cumulative Frequency Distributions

Cumulative Frequency Diagrams (CFDs) are the foundation for deriving the attainability tables. These curves were used to assess water-quality criteria ‘exceedance’ (or nonattainment based on the monthly average dissolved oxygen concentrations specified by designated use) in Chesapeake Bay tidal waters. Some observed spatial and temporal criteria exceedances do not have serious effects on ecological health or designated uses. Such exceedances are referred to as ‘allowable exceedances.’ Even when water quality is restored in the Chesapeake Bay and its tidal tributaries, certain areas will exceed the Chesapeake Bay water quality criteria, either due to poor flushing (chlorophyll *a*), a strong stratification event (dissolved oxygen), a wind resuspension event (water clarity) or some other natural phenomenon. A reference curve should reflect expected exceedances that occur naturally when the biological community is not impaired by the stressor(s) the criteria were designed to limit. Traditional regulatory assessments take 10 percent of the samples collected at a point and consider this amount to be ‘allowable exceedances’ that have limited impact on the designated use (U.S. EPA 1997). The 10 percent principle is not applicable in the context of the CFD methodology used herein for defining criteria attainment because it was designed for samples collected at one location and only reflects time variations.

CFDs offer the advantage of allowing the evaluation of both spatial and temporal variations in criteria exceedance. Methods currently used for assessing criteria attainment are based only on the frequency of exceedances because measurements are usually evaluated only at individual locations. In a water body the size of the Chesapeake Bay, accounting for spatial variation can be important and in that respect, the CFD approach represents a significant improvement over past methods. Developing a CFD is accomplished first by quantifying the spatial extent of criteria exceedance for every monitoring event during the assessment period. The compilation of estimates of spatial exceedance through time provides the capability to account for both spatial and temporal variation in criteria exceedance. Assessments are performed within spatial units defined by the intersection of monitoring segments and designated uses, and temporal units of three-year periods. Thus individual CFDs are developed for each spatial unit over three-year assessment periods. Details of the development of CFDs are described in the EPA’s *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for Chesapeake Bay and Its Tidal Tributaries* (U.S. EPA 2003).

The CFD is a graphical summary of criteria exceedance created by plotting temporal frequency on the vertical axis and spatial extent on the horizontal axis (Figure V-4). The resulting figure can be used to draw conclusions about the extent and pattern of criteria attainment or exceedance. The area under the curve represents a spatial and temporal composite index of criteria exceedance that is biologically acceptable and is used as the basis for defining criteria attainment for all Chesapeake Bay segments and designated uses.

A more appropriate approach for defining ‘allowable exceedances’ in the CFD context is to develop a reference curve, described above, that identifies the amount of spatial and temporal criteria exceedance that can occur without causing ecological degradation. Such curves are based on biological indicators of ecological health that are separate from the criteria measures and thus more closely reflect the needs of the Chesapeake Bay’s living resources. Biological indicators are used to identify areas of the Bay that have healthy ecological conditions. CFDs developed for those areas would reflect an extent and pattern of criteria exceedance that did not have ecological impact. In that way the reference curve approach takes the development of criteria levels beyond those developed in a laboratory setting and provides actual environmental context (U.S. EPA 2003).

The use of the reference curve and the interpretation of criteria attainment using the CFD is illustrated in Figure V-4. The dark blue (or bottom) line in the figure illustrates a possible reference curve, below which a certain amount of spatial or temporal exceedance is allowed. The black (or upper) line is an attainment curve, which is developed over every assessment period during which monitoring data are collected. The attainment curve is the assessment of the condition in the segment and it is compared to the reference curve, which serves as the benchmark. The area above the reference curve and below the attainment curve is the measure of criteria attainment and is referred to as ‘nonallowable exceedances.’

As the states adopt the Chesapeake Bay water quality criteria and concomitant implementation procedures into their water quality standards, they may decide to: 1) allow for no criteria exceedance, 2) select the normal distribution curve representing approximately 10 percent allowable criteria exceedance or 3) apply a biological reference curve. The first two options are likely to be more restrictive than the biological reference curve approach.

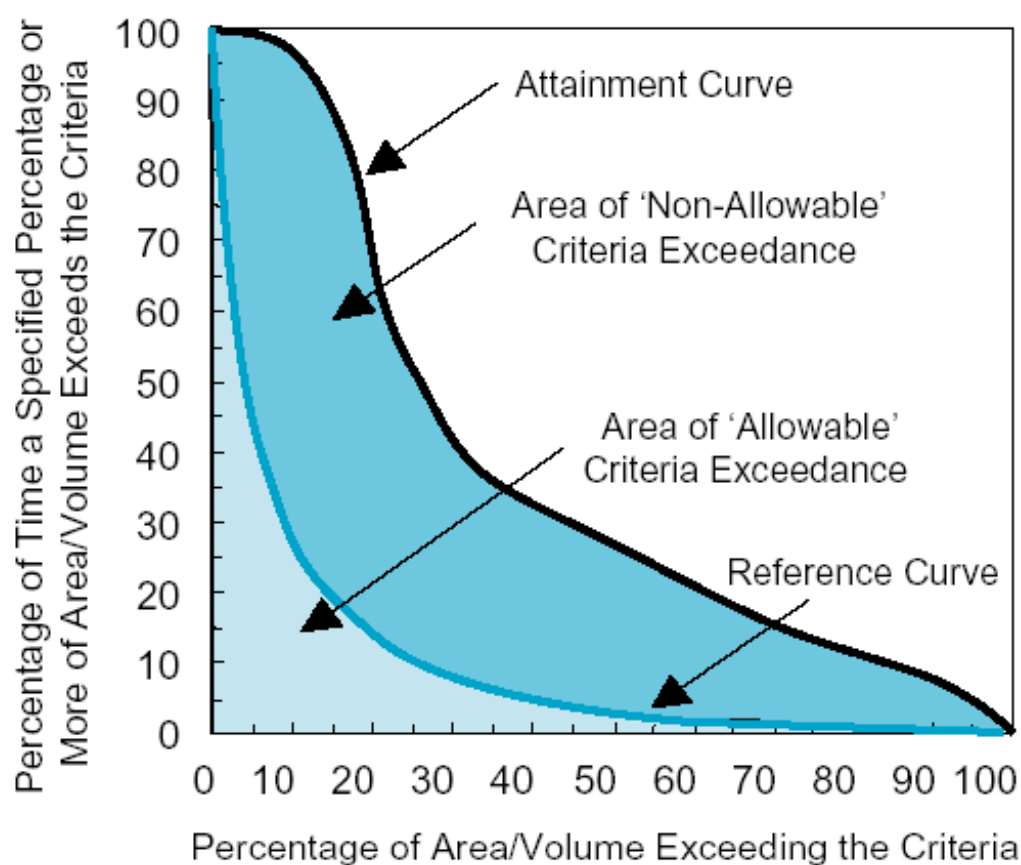


Figure V-4. Light area reflects amount of 'allowable' criteria exceedance defined as the area under the reference curve (light line). Dark area reflects the amount of 'non-allowable' criteria exceedance defined as the area between the attainment curve (black line) and the reference curve.

Applying the Kolmogorov-Smirnov Test for Criteria Attainability Using the CFD

The use of the Kolmogorov-Smirnov (KS) test had been considered early on to enhance the designated use attainability analyses for dissolved oxygen. However, the Chesapeake Bay Program partners determined that this test is really designed to assist decision making with regard to actual environmental attainment (U.S. EPA 2003). A statistical test is necessary because of limitations in the quantity of monitoring data that can be collected. Certainty will be a function of the amount of data available for the assessment, and the KS test provides a mechanism for accounting for different levels of certainty. The same situation does not exist for modeling information, which is used to assess attainability in this *Technical Support Document*. Models provide simulated data that have error characteristics that are inherently different than data collected in the field. As a result, application of a statistical test to model output would not necessarily provide results that are comparable to the same application to monitoring data. Thus, the application of the KS test for assessing attainability using model information is not appropriate. Models are used as a guide, not as a strict determination of attainability. The goal in using models for determining attainability and for defining allocations should be to achieve conditions where there are no non-allowable criteria exceedances. Therefore, the KS test is not used for the purpose of assessing attainability in this *Technical Support Document*.

However, for assessing attainment of water quality criteria, once these designated uses have been incorporated into state standards, using the KS test may be appropriate with environmental monitoring data to detect significant differences between the reference and assessment curves. The purpose in this case will be to account for differences in the certainty of either curve, which could result from differences in sampling rate or intensity. The test will provide a basis for distinguishing between a curve (reference or assessment) that is developed based on limited information and one that is based on detailed information.

The KS test was selected because it was developed for comparing two cumulative distribution functions such as the reference and assessment curves. The KS test is commonly used to detect significant deviations between two curves including those above and those below a reference curve (i.e., it is used as a ‘two-sided’ test). To assess Chesapeake Bay water quality criteria attainment, only deviations above the reference curve (i.e., non-allowable exceedances) are of interest and the test is being modified to detect only those deviations (i.e., to allow use as a ‘one-sided’ test).

Assessing criteria attainment will take place over specific units of space and time. Spatial units have been defined according to Chesapeake Bay Program monitoring segments and designated uses within each segment. Decisions regarding attainment will be made independently for each spatial unit, and monitoring data will be collected for three-year assessment periods in each spatial unit. Thus, separate CFDs will be developed for each spatial unit based on three years of monitoring data, and the KS test will be applied to each CFD for making decisions regarding attainment.

Use of the ‘10 Percent Default Reference Curve’ versus Biological Reference Curves

For most criteria components and designated uses, biologically-based reference curves are the preferred benchmark for evaluating CFDs and for defining the extent and pattern of allowable exceedances. However, biological information is not available in all cases and for those situations a default reference curve is needed. The default reference curve was developed on the basis of two principles: 1) limiting the amount of allowable exceedance to 10 percent of time and space combined; and 2) showing no preference for either spatial or temporal exceedance. The curve used for this purpose is a simple inverse curve that is forced through the 100 percent levels of temporal and spatial exceedance. In most cases, the biological references curves that have been developed are very similar to the default curve and it is considered to be a reasonable approach on that basis. However, actual biologically-based reference curves are the preferred approach and are used wherever possible (U.S. EPA 2003).

Consideration of Different Hydrology Periods

Currently, the CFD curves are generated from 10 years (1985–1994) of data and model output to assess attainment and nonattainment of criteria in model scenarios. However, compliance monitoring of the criteria adopted by the states may be performed using a more traditional three-year hydrology (U.S. EPA 2003). Analyses performed by the Chesapeake Bay Program staff and presented to the Chesapeake Bay Water Quality Steering Committee illustrates that the 10-year CFD is a better estimate of expected future attainment than any single 3-year period. Figure V-5 shows the 10-year attainability (tan dashes) versus the maximum, minimum, and average (black dashes and green dashes) 3-year attainability for the eight 3-year periods between 1985-1994. The range between maximum and minimum decreases as scenarios become closer to attainment for the 10-year period, and, in most cases, attainment is achieved almost simultaneously for the 10-year and 3-year averages.

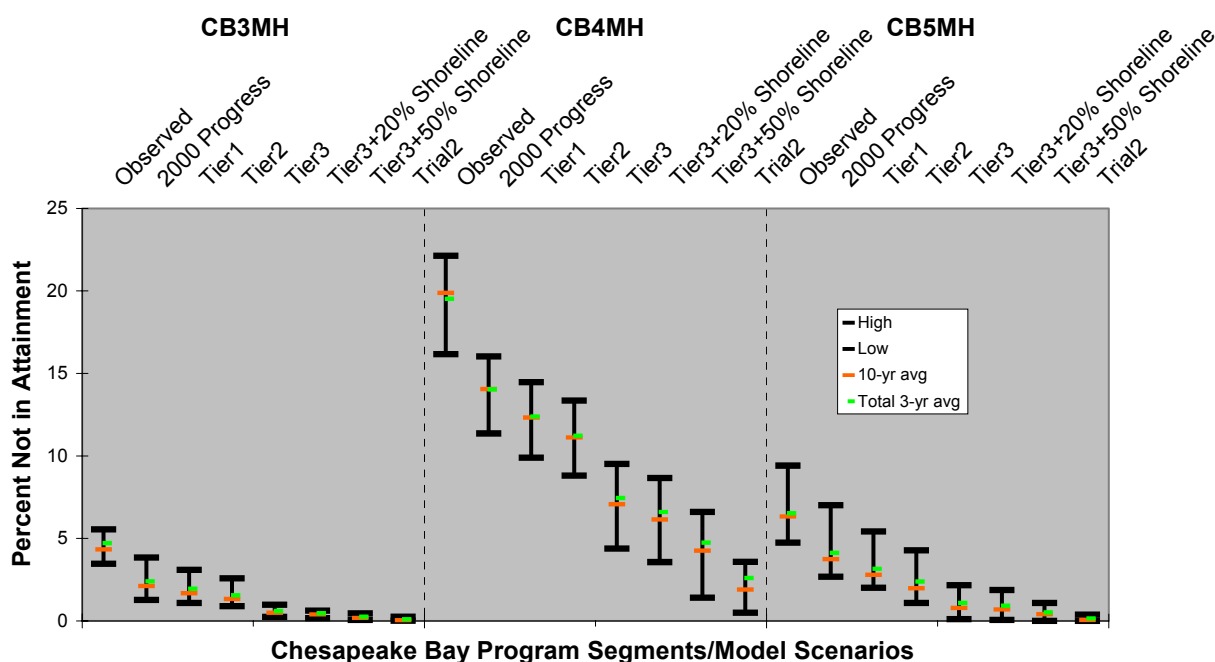


Figure V-5. Illustration of nonattainment of the deep-water dissolved oxygen criteria in Chesapeake Bay Program segments CB3MH, CB4MH and CB5MH using 3-year and 10-year averaging periods across eight different reduction scenarios.

Technological Attainability of the Open-Water, Deep-Water and Deep-Channel Designated Uses

The results of the analyses of the technological attainability of the open-water, deep-water and deep-channel designated uses are presented in a series of attainability tables (tables V-5 and V-6). The 'Observed' column in each table represents current conditions in the Chesapeake Bay and tidal tributaries derived from 1985-1994 Chesapeake Bay water quality monitoring program data. The data are aggregated by month and interpolated across all Chesapeake Bay tidal waters. The CFD is constructed from violations in the interpolated data. The attainability of all other scenarios is obtained by comparing the model scenario to the model calibration on a point-by-point and month-by-month basis. The change in the model predictions due to the management actions in the scenario is applied to the observed 1985-1994 data. This 'scenario-modified' data set is then aggregated, interpolated, and used in the CFD to determine the attainability results (see Chapter III; Linker et al. 2002).

The letter 'A' in the tables denotes attainment (i.e., 0 percent nonattainment), and the numbers represent percent nonattainment for each segment as determined using the biological reference curves described above. Percent nonattainment values of less than 1 percent were considered in attainment for purposes of these analyses by the Chesapeake Bay Program partners. There are multiple examples where very small percent nonattainment values (< 1 percent) were observed

across scenarios spanning large differences in nutrient reductions. These small, less than 1 percent nonattainment values are an artifact of the overall CFD/reference criteria attainment assessment methodology.

The analyses presented in this section will show that, with the exception of a few segments in Chesapeake Bay tidal waters, the dissolved oxygen criteria protecting of the designated uses are attained by reductions represented by the E3 scenario. For Tier 3, these same analyses show that the dissolved oxygen criteria protecting designated uses in some segments, particularly for deep-water uses in certain mainstem segments, do not achieve full attainment.

Migratory Fish and Spawning and Nursery Designated Use Attainability

The monthly average dissolved oxygen concentration of 6 mg/l applied to the migratory and spawning designated use habitats shows attainment is achieved in all segments where this use would apply in the Chesapeake Bay and its tidal tributaries with one exception (Table V-5). There is a certain amount of nonattainment simulated in the lower Mattaponi River segment (see *Open-Water Use Attainability* below for an explanation). Recognizing the actual criteria protective of this use are 6 mg/l 7-day mean and 5 mg/l instantaneous mean dissolved oxygen concentrations, the migratory fish spawning and nursery designated use can essentially be attained under current conditions and should not be an issue in the near future as long as responsible pollution prevention and control measures are maintained.

Open-Water Fish and Shellfish Designated Use Attainability

Table V-6 presents the results of the attainability analyses for monthly average dissolved oxygen concentrations of 5, 3- and 1 mg/l, respectively, applied to the open-water, deep-water and deep-channel designated uses. Full attainment is rare for the open-water use under observed conditions. However, at reduction levels represented by Tier 3, attainment for most segments is achieved for this refined designated use. Outside of the Mattaponi and Pamunkey rivers, only the western Lower Chesapeake Bay (1.3 percent) and the Lower Choptank River (1.1 percent) segments had nonattainment levels above 1 percent at reduction levels represented by Tier 3. The jurisdictions will need to determine the significance of any degree of non-attainment during the development of their individual UAAs. Complete attainment is generally observed in the open-water designated use habitats at reduction levels equal to The E3 scenario. Natural lower dissolved oxygen conditions result from the wetland areas of the Mattaponi and Pamunkey rivers in segments MPNTF, MPNOH, PMKTF, and PMKOH (see Table V-6).

Extensive tidal wetlands lining most of the shorelines of the Mattaponi and Pamunkey rivers cause a natural oxygen deficit in the tidal-fresh and oligohaline areas. These areas consist of productive tidal wetlands which create extensive amounts of biomass that consume vast quantities of oxygen as they decompose. In these segments, the natural oxygen demand from wetland sediments directly influences dissolved oxygen criteria attainment. Recent studies

estimate wetland sediment oxygen demand to range from 1-5.3 grams oxygen meter²-day (Neubauer et al. 2000; Chi et al. 1999). The Chesapeake Bay Program Water Quality Model was recalibrated to account for this phenomenon that occurs in relatively small bodies of water such as the Mattaponi and Pamunkey rivers. In the model, a uniform oxygen demand of 2 grams oxygen meter²-day was used. The effect of this wetland sediment oxygen demand is most evident in the Chesapeake Bay Program segments where there are extensive tidal wetlands which border relatively small bodies of water, such as in the Mattaponi and Pamunkey rivers.

Table V-5. Percent nonattainment of a monthly averaged 6 mg/l dissolved oxygen concentration applied to migratory spawning and nursery designated uses.

Chesapeake Bay Program Segment	Model Scenarios							
	Observed	Progress 2000	Tier 1	Tier 2	Tier 3	Tier 3 + 20%	Tier 3 + 50%	E3
Northern Chesapeake Bay (CB1TF)	A	A	A	A	A	A	A	A
Upper Chesapeake Bay (CB2OH)	A	A	A	A	A	A	A	A
Central Chesapeake Bay (CB3MH)	0.19	A	A	A	A	A	A	A
Upper Patuxent River (PAXTF)	A	A	A	A	A	A	A	A
Middle Patuxent River (PAXOH)	A	A	A	A	A	A	A	A
Lower Patuxent River (PAXMH)	A	A	A	A	A	A	A	A
Upper Potomac River (POTTF)	A	A	A	A	A	A	A	A
Middle Potomac (POTOH)	A	A	A	A	A	A	A	A
Lower Potomac (POTMH)	A	A	A	A	A	A	A	A
Upper Rappahannock (RPPTF)	A	A	A	A	A	A	A	A
Middle Rappahannock (RPPOH)	A	A	A	A	A	A	A	A
Lower Rappahannock (RPPMH)	A	A	A	A	A	A	A	A
Upper Mattaponi (MPNTF)	A	A	A	A	A	A	A	A
Lower Mattaponi (MPNOH)	A	A	A	1.72	2.78	2.40	1.79	6.08
Upper Pamunkey River (PMKTF)	A	A	A	A	A	A	A	0.10
Lower Pamunkey River (PMKOH)	A	A	A	A	A	A	A	A
Middle York River (YRKMH)	A	A	A	A	A	A	A	A
Upper James River (JMSTF)	A	A	A	A	A	A	A	A
Middle James River (JMSOH)	A	A	A	A	A	A	A	A
Lower James River (JMSMH)	A	A	A	A	A	A	A	A
Eastern Bay (EASMH)	A	A	A	A	A	A	A	A
Middle Choptank River (CHOOH)	A	A	A	A	A	A	A	A
Lower Choptank River (CHOMH1)	A	A	A	A	A	A	A	A
Mouth of the Choptank River (CHOMH2)	A	A	A	A	A	A	A	A

Table V-6. Percent nonattainment of monthly averaged 5, 3 and 1 mg/l dissolved oxygen concentrations applied to open-water, deep-water and deep-channel designated uses.

Chesapeake Bay Program Segment	Model Scenarios								
	DU	Observed	Progress 2000	Tier1	Tier2	Tier3	Tier 3 + 20%	Tier 3 + 50%	E3
Northern Chesapeake Bay (CB1TF)	OW	A	A	A	A	A	A	A	A
Upper Chesapeake Bay (CB2OH)	OW	1.92	0.88	0.68	0.43	0.17	0.13	0.07	A
Upper Central Chesapeake Bay (CB3MH)	OW	A	A	A	A	A	A	A	A
	DW	4.18	2.52	2.24	1.61	0.73	0.54	0.37	A
	DC	13.52	8.16	7.21	5.03	1.84	1.24	0.11	A
Middle Central Chesapeake Bay (CB4MH)	OW	0.05	A	A	A	A	A	A	A
	DW	19.64	15.28	14.28	12.05	8.51	7.57	5.62	0.69
	DC	45.19	32.75	28.94	18.81	3.93	2.69	1.00	A
Lower Central Chesapeake Bay (CB5MH)	OW	A	A	A	A	A	A	A	A
	DW	6.16	4.38	3.75	2.58	1.08	1.00	0.72	A
	DC	13.79	7.76	6.00	2.59	0.15	0.14	0.11	A
Western Lower Chesapeake Bay (CB6PH)	OW	5.87	4.26	3.68	2.71	1.30	1.23	0.99	0.01
	DW	0.36	0.01	A	A	A	A	A	A
Eastern Lower Chesapeake Bay (CB7PH)	OW	4.55	3.31	2.81	1.82	0.74	0.66	0.49	A
	DW	A	A	A	A	A	A	A	A
Mouth of Chesapeake Bay (CB8PH)	OW	A	A	A	A	A	A	A	A
Upper Patuxent River (PAXTF)	OW	A	A	A	A	A	A	A	0.38
Middle Patuxent River (PAXOH)	OW	9.79	1.56	1.84	1.62	0.86	0.36	0.11	A
Lower Patuxent River (PAXMH)	OW	7.40	1.59	1.69	1.04	0.01	A	A	A
	DW	5.52	0.85	0.82	0.50	0.07	0.02	A	A
Upper Potomac River (POTTF)	OW	A	A	A	A	A	A	A	A
Middle Potomac (POTOH)	OW	2.10	1.36	1.08	0.63	0.31	0.30	0.25	0.01
Lower Potomac (POTMH)	OW	0.78	A	A	A	A	A	A	A
	DW	6.90	5.03	4.53	3.11	1.12	0.70	0.15	A
	DC	18.89	11.39	8.64	5.07	0.19	0.17	0.16	A
Upper Rappahannock River (RPPTF)	OW	A	A	A	A	A	A	A	A
Middle Rappahannock River (RPPOH)	OW	A	A	A	A	A	A	A	A
Lower Rappahanock River (RPPMH)	OW	0.44	0.27	0.10	A	A	A	A	A
	DW	5.58	2.61	1.09	0.01	A	A	A	A
	DC	6.39	5.20	3.38	1.65	A	A	A	A
Piankatank River (PIAMH)	OW	0.12	A	A	A	A	A	A	A
Upper Mattaponi River (MPNTF)	OW	33.26	27.37	25.87	27.23	33.73	32.44	30.50	52.14
Lower Mattaponi River (MPNOH)	OW	46.88	31.00	28.95	31.86	28.99	26.88	19.11	48.11
Upper Pamunkey River (PMKTF)	OW	62.25	49.53	42.07	30.35	32.94	21.16	10.32	54.50
Lower Pamunkey (PMKOH)	OW	42.15	15.22	12.66	13.86	10.32	4.52	1.06	11.39

Chesapeake Bay Program Segment	Model Scenarios								
	DU	Observed	Progress 2000	Tier1	Tier2	Tier3	Tier 3 + 20%	Tier 3 + 50%	E3
Middle York River (YRKMH)	OW	18.08	4.85	3.31	2.32	0.42	0.23	0.03	A
Lower York River (YRKPH)	OW	1.48	0.01	A	A	A	A	A	A
	DW	0.01	A	A	A	A	A	A	A
Mobjack Bay (MOBPH)	OW	2.30	1.78	1.60	1.10	0.34	0.29	0.23	A
Upper James River (JMSTF)	OW	0.66	A	A	A	A	A	A	A
Middle James River (JMSOH)	OW	A	A	A	A	A	A	A	A
Lower James River (JMSMH)	OW	A	A	A	A	A	A	A	A
Mouth of the James River (JMSPH)	OW	A	A	A	A	A	A	A	A
Eastern Bay (EASMH)	OW	A	A	A	A	A	A	A	A
	DW	3.26	2.18	2.00	0.90	0.36	0.32	0.20	A
	DC	20.23	12.87	11.26	6.49	0.67	0.10	0.01	A
Middle Choptank River (CHOOH)	OW	0.14	A	A	A	A	A	A	A
Lower Choptank River (CHOMH1)	OW	2.27	1.83	1.78	1.51	1.08	0.92	0.74	0.43
Mouth of the Choptank River (CHOMH2)	OW	0.33	A	A	A	A	A	A	A
Tangier Sound (TANMH)	OW	0.15	0.06	0.06	0.05	0.36	0.31	0.84	0.22
Lower Pocomoke River (POCMH)	OW	A	A	A	A	A	A	A	A

*A = Attainment; the number provides an estimate of percent nonattainment.

Deep-Water Seasonal Fish and Shellfish Designated Use Attainability

As Figure V-6 illustrates, the deep-water designated use (assessed with a monthly dissolved oxygen concentration of 3 mg/l) is not currently attained in any Chesapeake Bay Program segments under observed conditions with the exception of the eastern lower Chesapeake Bay (CB7PH). Some degree of attainment is seen at reductions levels equivalent to Tier 2. At Tier 3, nonattainment persists in several major segments. Attainment is achieved in all of the segments at reduction levels represented by The E3 scenario.

Deep-Channel Seasonal Refuge Designated Use Attainability

The monthly average 1 mg/l dissolved oxygen concentration, that applies to deep-channel designated use habitats, is not attained under observed conditions (Table V-6). However, the percent non-attainment decreases with increasing load reductions, until attainment is achieved in all segments at reduction levels represented to The E3 scenario. Even at levels of reduction represented by Tier 3 almost complete attainment is realized.

SEDIMENT REDUCTION AND ITS EFFECT ON WATER QUALITY

Shoreline-erosion sediment reductions beyond the BMPs considered in the tiered scenarios do not have a significant affect on the dissolved oxygen water quality response. Tables V-5 and V-6 include model scenarios labeled 'Tier 3 + 20%' and 'Tier 3 + 50%.' These are scenarios where additional shoreline sediment loads (20 percent and 50 percent beyond year 2000 levels, respectively) have been reduced beyond that which occurs in Tier 3. As shown in the attainability tables for dissolved oxygen (Table V-5 and V-6), a 20 percent shoreline reduction in sediment beyond the tiers (which is considered by the Chesapeake Bay Program partners to be difficult, at best, to achieve) results in a less than 1 percent improvement in, for example, segment CB4MH deep-water use. Even a 50 percent reduction in shoreline erosion (considered not feasible to achieve by the Chesapeake Bay Program partners) results in a less than 3 percent improvement in attainment of the dissolved oxygen criteria for that same segment. While shoreline sediment load reductions may not significantly improve dissolved oxygen conditions in the deep-water and deep-channel monitoring segments, it can have positive effects on water clarity in shallow-water areas. Reduction of sediment loads remains a critical component to the restoration of underwater bay grasses.

Work is continuing to examine the degree and cause of the model-simulated sediment reduction and resultant water quality responses (dissolved oxygen, water clarity and chlorophyll *a*). Greater sequestering and retention of nutrients in the shallows may be due to increased underwater bay grass and benthic algae in the shallows (caused by improved light conditions resulting from reduced sediment). Decreases in shoreline sediment loads in the shallows would also have a positive effect on benthic filter feeders, which may also cause greater nutrient retention in shallow sediment. Simulated shoreline sediment loads are associated with soil phosphorus loads as well as negligible nitrogen loads, and the contributing effect of these nutrient reductions associated with shoreline sediment reductions needs to be assessed as well. For these reasons, sediment reduction will be targeted more for underwater bay grass restoration than for dissolved oxygen improvement. The Chesapeake Bay Program partners are evaluating the value of targeting sediment reduction to specific underwater bay grass sensitive areas for more effective restoration results.

ATTAINABILITY OF THE SHALLOW-WATER DESIGNATED USE

Attaining the Shallow-Water Bay Grass Designated Use

While water clarity is the criteria that will be applicable to the shallow-water designated use (U.S. EPA 2003), attainability is not being assessed on the basis of this parameter, as is the case for the dissolved oxygen criteria for the other designated uses. The Chesapeake Bay Watershed and Water Quality Models have been extensively refined over many years to accurately measure water quality responses of nutrient reduction practices in terms of improvements in ambient dissolved oxygen concentrations (see Table III-3). Chesapeake Bay watershed modeling of sediment sources and transport and Bay water quality modeling of water sediment transport and resuspension has not yet reached this level of sophistication. Thus, the Chesapeake Bay Program partners agreed to assess attainability for the shallow-water designated use based on the presence of underwater bay grasses which offers the added advantage of providing a more direct measure

of Bay restoration.

Because attainment with water quality standards will ultimately be based, in part, on the acreage of underwater bay grasses per segment, the measurement of *attainability*, for purposes of this *Technical Support Document*, will also be based on underwater bay grasses. The attainability of the shallow-water designated use has been assessed based on the following concepts:

- The restoration goal was based on the historical and recent presence of underwater bay grasses;
- The methodology for setting the acreage restoration goal is conservative;
- The natural coverage of underwater bay grasses is potentially greater than the restoration goal;
- Reasonable time frames within which to assess attainment of the underwater bay grass goal are incorporated into the criteria implementation recommendations; and
- Implementation of the shallow-water designated use allows for a flexible approach to determine use attainability.

Because the restoration target for the shallow-water designated use is 185,000 acres of underwater bay grasses based on their actual presence in the recent and historical past (see Chapter IV), this use is considered to be attainable. There is compelling evidence that such conditions once existed and can exist again, especially after states have completed their tributary strategies, adopted new water quality standards and have begun to implement restoration measures.

The methodology for setting the acreage goal is conservative in that a set of decision rules (described in Chapter IV) were applied to ensure that the goal did not require restoring underwater bay grasses to areas deeper than the amount of light was expected to reach the Bay bottom in each segment by 2010. To do this, it was required that at least 20 percent of each depth zone (0-0.5, 0.5-1 or 1-2 meters) be covered by underwater bay grass in that single best year (an acute presence threshold), or 10 percent of that area be covered at some time during three of four five-year intervals (a chronic presence threshold) in order for those underwater bay grasses to be included in the total (i.e., all underwater bay grass growing deeper than these areas was not included).

Additionally, the restoration goal of 185,000 is actually less than the potential underwater bay grasses natural coverage. The total shallow-water habitat available for underwater bay grasses in the Chesapeake Bay from the shoreline to a depth of 2 meters is just over 640,000 acres. On average, underwater bay grasses cover approximately 35 percent of the available shallow-water habitat (see Chapter IV). Therefore, at any given time in the past it is likely that the Chesapeake Bay had as much as 225,000 acres of underwater bay grasses (based on 35 percent occupation of the 640,000 acreages of potential bay grass habitat). Within the application depths set by the shallow-water designated uses, there are just under 496,000 acres of habitat. Given the occupation rate described above, provided that light levels reach the proposed segment-specific

depths, it is reasonable to assume that a goal of 185,000 acres is attainable (37 percent of 496,000 acres of shallow-water habitat).

It is important to note that weather plays a key role in annual underwater bay grass abundance. An untimely hurricane or algae bloom may suppress underwater bay grass-growth despite management actions. It is thus unreasonable to expect that underwater bay grass goals will be reached consistently, each year. The EPA *Regional Criteria* makes accommodations for the need to identify a reasonable time frame for assessing attainment by recommending that achievement of the underwater bay grass goal be determined on the basis of the single best year during a three-year period (U.S. EPA 2003).

Finally, as summarized in Chapter IV and described in EPA 2003, states have options for defining attainment of the shallow-water designated use that allows for meeting either the water clarity criteria out to a segment-specific depth, the recommended underwater bay grass acreage by segment or the water clarity criteria over the established acreage of shallow-water habitat required to support meeting the restoration goal.

MEASURES TO ATTAIN THE SHALLOW-WATER DESIGNATED USE

The restoration of underwater bay grasses and the achievement of the water clarity criteria will depend on reductions in sediment across the watershed. Sediment reductions associated with the tiers are those that are achieved in the process of conducting BMPs to remove nutrients. Additional sediment reduction measures may be implemented, especially in nearshore areas closer to the tidal Bay waters, which have not been captured in the tier scenario reductions. In February 2003 the Chesapeake Bay Program conducted a workshop to explore additional sediment reduction opportunities. This workshop yielded a menu listing the various types and efficiencies of sediment BMPs available to assist in achievement of the Bay sediment reduction goals (Chesapeake Bay Program 2003). The menu includes the following BMPs for consideration by the jurisdictions in developing their tributary strategies:

Stream/Riverine BMPs

- Riparian buffers
- Stream restoration
- Urban storm water management

Shoreline BMPs

- Structural shoreline erosion controls
- Offshore breakwaters
- Breakwater systems (includes structures/beach nourishment/marsh)
- Headland control

In-Water BMPs

- Bay grass planting

- Oyster reef restoration and oyster aquaculture

Where available, the report provides information on each BMP's definition, impact, sediment and nutrient reduction efficiencies, potential problems, costs estimates and possible funding sources.

The report concludes that based on initial reviews of efficiencies and reasonable application, current sediment BMPs are likely to reduce shoreline and nearshore sediment inputs/resuspension by about 10 to 20 percent overall. Generally, shoreline and nearshore practices can provide local clarity improvements. However, these practices tend to be costly. A targeted approach is recommended that focuses on reducing controllable sources near the most critical living underwater bay grass areas in order to extract the most efficient cost per water quality improvement.